Conference Paper

Ecological and Geographical Gis-Analysis of Anomalies in Amphibians of Ukraine

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Abstract

GIS modeling of 138 georeferenced point data of anomalies in amphibians in Ukraine (data from both the literature and personal field surveys) revealed a rather poor, but statistically significant correlation of the numbers of anomalies with the anthropogenic impact measured by the Human Footprint (r=0,268, p=0,0025). We consider that in certain cases the abundance of anomalies in amphibians could be used for purposes of bioindication.

Keywords: anomalies in amphibians, GIS-analysis.

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1. Introduction

For natural ecosystems in general and for amphibian populations in particular, anthropogenic impact is a very important factor. This factor is multidimensional, as it has direct and mediated aspects of influence. The decline of amphibian populations and the destruction of their natural environment are related to direct aspects of anthropogenic impact. While the emergence of specific morphological malformations is related to mediated factors of anthropogenic influence, such as pollution and other negative transformations of natural habitat.

Scientists have discovered, that morphological abnormalities originate more often in amphibians than in other terrestrial vertebrates [1, 3, 5]. Herewith an occurrence of amphibians with abnormalities in natural populations up to the level of 1.5-5% is considered normal [4, 9]. Such malformations could be genetically caused or acquired during the lifetime. The observation, that in isolated urban populations of moor frogs and marsh frogs, where the increased impact of mutagens cause abnormalities to emerge more often, than in other populations in more preferable conditions, is evidence of the sensitivity of the species to the anthropogenic "burden" [13–15, 23]. But this is not the only environment, where higher malformational rates occur. For example in agrocenosises there were also big quantity of abnormalities of intestines (including gonads) observed among hybrids and edible frogs [13]. Pestidical pollution of water reservoirs that leads to physiological and morphological changes in populations of green frogs, does also have a direct impact on their genome [24]. Hydrochemical water parameters (for example pH) have been found to influence the survival rate of amphibians and their morphogenesis in combination with other factors. In particular by forming of various morphological malformations [7].

2. Methods

To get a full picture of the effects of different possible factors on amphibian populations in the Ukrainian territory we used GIS-modeling and data visualization based on various indicators and factors found online [22]. In the SAGA GIS (version 2.2.5) package 138 georeferenced records of anomalies in amphibians (based on original and literature data - Marushchak, Muravynets, 2013; Fedoniuk, 2008; Kurtiak, 2010; Mikitinets, 2014) have been used to extract the information contained in GIS environmental layers reflecting the bioclimate, land use, anthropogenic impact etc. The extracted information was kept in GIS layers. We got a 138X40 matrix, where the percentage of abnormalities in each sample of amphibians was considered. This information was analyzed in Statistica 8 pack using the method of multiple regression. The percentage of abnormalities was regarded as a dependent variable, and the other 39 - as independent.

We also used the bioclimatic parameters that are derived from the data on average monthly temperatures and precipitation. These variables are often used for modeling ecological niches, for example, when using such algorithms as the BIOCLIM (Busby, 1991; [22]).

We analyzed the confinement of habitats by comparing malformation levels in each area to the degree of influence of anthropogenic factors. As the initial parameters of anthropogenic burden the data from the interactive global map of human impact index (Human Footprint, HF), created in the Columbia combined forces of Wildlife Conservation Society (WCS) and the International Information Centre for Geosciences (CIESIN) in 2004 (Wildlife Conservation Society & Center for International Earth Science Information Network, Columbia University, 2005) [20] were used. This raster combines the layers representing the demographic parameters, land use indicators, infrastructure and access to territories.

From the European system ESDAC (European Soil Data Centre), which provides the European Union with all necessary soil information, we took GIS-maps showing the spreading of different soil types (max – 28 types) and levels of soils' pH.

For quantitative assessment of plant covering during the vegetation season (April-September) we used the normal derivative vegetation index (NDVI). This is an indicator for photosynthetic active biomass.

Additionally special metrics were applied to textural pictures of plant layers to understand the heterogenic patterns of the studied habitats [21].

3. Results

As a result of our work it can be concluded, that on huge territories it is hard to single out particular factors of one-way influence. Ecological problems and their impact on the occurrence of morphological abnormalities are best to be studied on a regional level. Alternatively classification principle could be used to combine territories and spheres of impact (ecological problems). Only for the index of anthropogenic influence (Human Footprint) we managed to show a particular impact on the variation of the dependent variable (the percentage of abnormalities in samples), although the correlation is fairly poor ($r=0.268$), however statistically significant ($p=0.0025$).

For a visual representation of the spread of amphibian abnormalities in Ukraine, using the spatial interpolation method (multilevel B-spline interpolation) in SAGA GIS, a map was compiled, where different colors correspond to the estimated percentage of abnormalities in amphibians (Figure 1).

4. Conclusion

It was concluded that, despite the fact that the nature of the abnormalities may be different and have complicated patterns, it can also be associated with a set of factors that are caused by human impact. It can be seen in relation to the index of human impact (Human Footprint) correlating weakly ($r = 0.268$), but significantly ($p = 0.0025$) with the percentage of malformations. This underlines the possible impact of different groups of anthropogenic factors, physical, chemical, biological, etc., acting on amphibian populations as multiple stressors, even an increase in dragonfly predators due to warmer temperatures [19]. Most likely amphibians are being subjected to a variety of human-induced impacts that are related to water quality. Special attention must be given to the presence of pollutants, pathogens, and global environmental changes that

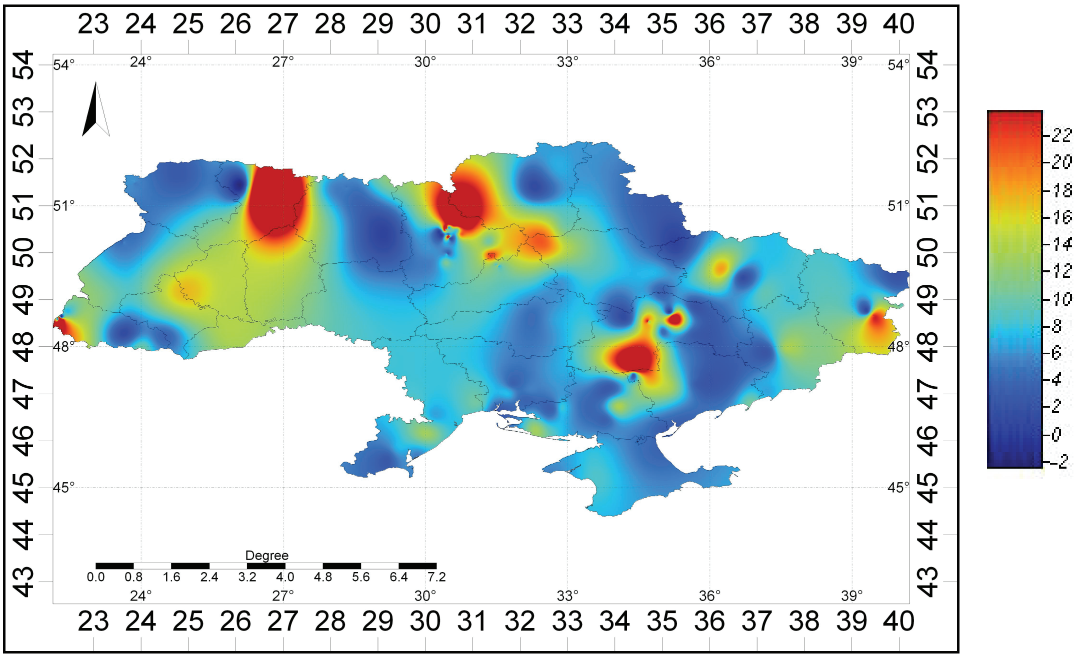

Figure 1: The spatial interpolation model showing the frequency of abnormalities' occurrence in amphibians of Ukraine, compiled with the help of SAGA GIS program.

may affect amphibian growth and development, increase mortality, and eventually lead to population declines [2].

In our opinion, from a methodical standpoint the occurrence of abnormalities in amphibians may be used for bioindication and identification of adverse trends in the deterioration of the environment.

Since environmental factors have a strong spatial component, GIS is ideally suited to investigating stressors that might be responsible and hence it is a powerful analytical tool to understand the causes of amphibian population declines in particular environmental settings and stimulate further research [18].

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